Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE EVALUATION OF THE BIOMASS QUALITY OF TALL OATGRASS, *Arrhenatherum elatius* (L.) Beauv, AND PROSPECTS OF ITS USE IN MOLDOVA

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Abstract

The main objective of this research was to evaluate the quality indices of green mass, hay, silage and straw from the local ecotype of tall oatgrass, Arrhenatherum elatius, grown in monoculture in the experimental plot of NBGI, Chisinau, Republic of Moldova. The results revealed that the harvested green mass contained 25.0-29.8% dry matter. The dry matter of the whole plant contained 80 g/kg CP6yy, 382 g/kg CF, 83 g/kg ash, 411 g/kg ADF, 710 g/kg NDF, 38 g/kg ADL,118 g/kg TSS, 373 g/kg Cel, 299 g/kg HC, with nutritive and energy value 58.2% DMD, 51.3% DOM, 9.29 MJ/kg ME and 5.31 MJ/kg NEl. The biochemical composition, nutritive and energy value of tall oatgrass hay: 77 g/kg CP, 414 g/kg CF, 80 g/kg ash, 436 g/kg ADF, 740 g/kg NDF, 40 g/kg ADL, 98 g/kg TSS, 396 g/kg Cel and 304 g/kg HC, 9.00 MJ/kg ME and 5.02 MJ/kg NEl. The tall oatgrass fermented fodder- silage is characterized by pH = 4.26, 5.9 g/kg acetic acid, 18.3 g/kg lactic acid and free of butyric acid, 88 g/kg CP, 405 g/kg CF, 100 g/kg ash, 420 g/kg ADF, 724 g/kg NDF, 26 g/kg ADL, 74 g/kg TSS, 394 g/kg Cel, 304 g/kg HC, with nutritive and energy value 56.5% DMD, 9.19 MJ/kg ME, 5.21 MJ/kg NEl. The tall oatgrass straw contained 50 g/kg CP, 51 g/kg ADL, 85 g/kg TSS, 405 g/kg Cel, 286 g/kg HC. The tall oatgrass substrates used for anaerobic digestion have optimal amount of lignin and hemicellulose, the estimated biochemical methane potential varied from 341 to 361 l/kg VS. The tall oatgrass straw and hay may be used as feedstock for the production by cellulosic ethanol, the estimated theoretical ethanol yield from cell wall carbohydrates averaged 507-509 L/t.

Key words: *Arrhenatherum elatius, biomass quality indices, forages, substrates for renewable energy production.*

INTRODUCTION

The family Poaceae containing 777 plant genera and 11461 accepted species, constitutes one of the world's most economically important plant groups. The *Plant List* includes 96 scientific plant names of species rank for the genus *Arrhenatherum*, 9 of these are accepted species names with Eurasian and North African distribution. In the spontaneous flora of the Republic of Moldova, there is one species, *Arrhenatherum elatius* (L.) Beauv is commonly known as tall oat-grass, bulbous oat grass or false oat-grass.

Arrhenatherum elatius is a perennial plant, loosely cespitose, sometimes rhizomatous, rhizomes to 3 mm thick. The culms grow 50-140(180) cm tall, with 4-5 nodes, glabrous, unbranched, the basal internodes may be swollen or not swollen; the nodes – glabrous or occasionally puberulent to densely hairy. Young leaves convolute; sheaths split, with overlapping margins; ligules membranous, 1- 3 mm long, obtuse to truncate, usually ciliate; blades without auricles, long (up to 40 cm), their width increasing from the base to about two-thirds of their length, then decreasing to give an acuminate tip; upper surface, smooth, ribless; lower with marked keel. Flag leaves shorter, widest at their base and the keel not well developed. The inflorescences are lax panicles, 20-30 cm long and 2-7 cm wide green, shiny, becoming stramineous, sometimes purple-tinged; branches 15-20 mm long, ascending to divergent, verticillate, usually spikelet-bearing at the base; pedicels 1-10 mm long. Spikelets usually 2-flowered, the lower male only, the upper hermaphrodite; sometimes a third, fourth or even fifth floret may be present, hermaphrodite or rudimentary; the lowest floret also sometimes hermaphrodite. Glumes membranous, unequal, the lower 1-nerved and shorter, the upper 3 -nerved and longer. Lower floret with a long, twisted, geniculate awn, inserted one-third from base of the lemma; the upper floret generally awnless, but when present

usually straight and inserted near the tip of the lemma. Flowering time - May-June, cross-pollinated and wind-pollinated. Caryopses 4-5 mm long, about 1.2 mm wide, ellipsoid, densely hairy, yellowish. The weight of 1000 seeds 2.6-3.1 g. $2n = 14, 28, 42$. It is propagated by sowing. The fibrous roots are stout. The lowest temperature for seed germination of tall oat-grass is 3-4°C, seedlings can tolerate low temperatures from -2°C to -4°C, adult plants can still grow slowly at low temperatures from -3°C to -4°C, but suffer at -6°C. In winter, the plants tolerate temperatures down to -23°C. *Arrhenatherum elatius* occurs on different types of soils, with a pH between 5 and 8 and medium salinity, prefer full sun or half-shady places. It is a mesophytic to xerophytic species of open habitats: dry grassland, edges of woods, disturbed ground, successional fields, hayfields, pastures, thickets, and roadsides, sometimes becoming a dominant grass in fields. It can colonize and stabilize limestone scree, bare calcareous cliffs, maritime shingle and coastal dunes. *Arrhenatherum elatius* is grown as a forage grass; it recovers quickly after grazing, but it does not withstand overgrazing. It is sown in mixtures with other species for grassland restoration (Medvedev & Smetannikova, 1981; Maczey, 2015).

Currently, *Arrhenatherion elatioris* is being assessed for its potential suitability for energy biomass production (Moudrý et al., 2010; Raclavská et al., 2011; Ebeling et al., 2013; Boob et al., 2019; Danielewicz et al., 2019; Jezerska et al.,2019;Waliszewska et al., 2021).

The main objective of this research was to evaluate the quality indices of green mass, hay, silage and straw from the local ecotype of tall oatgrass, *Arrhenatherum elatius*, as feed for livestock, also as substrates for renewable energy production.

MATERIALS AND METHODS

The local ecotype of tall oatgrass, *Arrhenatherum elatius*, grown in monoculture in the experimental sector of the National Botanical Garden (Institute) of Moldova, Chişinău, N 46°58′25.7″ and E 28°52′57.8″, served as subject of research and the fodder plants: meadow fescue, *Festuca pratensis,* common oat *Avena sativa* 'Sorin' and winter barley *Hordeum vulgare* 'Excelent', were used as controls. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 m^2. The samples were collected in the second growing season and the first cut was done in the pre-flowering stage. The harvested plants were chopped into 1.5-2.0 cm small pieces, with a laboratory forage chopper; the dry matter content was detected by drying the samples to a constant weight, at 105°C. The prepared hay was dried directly in the field. For ensiling, the green mass was chopped by using a forage chopping unit, shredded and compressed in well-sealed glass containers, stored at ambient temperature (18-20°C). After 45 days, the containers were opened, and the sensorial and chemical characteristics of the prepared silages were determined in accordance with standard laboratory procedures and the Moldavian standard SM 108 for forage quality analysis. Straws were collected after the grains have been removed. For chemical analyses, plant samples were dried in a forced air oven at 60 °C, milled in a beater mill equipped with a sieve with diameter of openings of 1 mm and some of the main biochemical parameters were assessed: crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM) and digestible organic matter (DOM) were determined by the near infrared spectroscopy (NIRS) technique PERTEN DA 7200 at the Research and Development Institute for Grasslands, Braşov, Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures.

The carbon content of the substrates was determined using an empirical equation according to Badger et al. (1979). The biochemical methane potential was calculated according to the equations of Dandikas et al. (2015). The theoretical ethanol potential (TEP) was calculated according to the equations of Goff et al. (2010) based on conversion of hexose (H) and pentose (P) sugars.

RESULTS AND DISCUSSIONS

Analysing the results of the fresh mass quality of the local ecotype of tall oatgrass, *Arrhenatherum elatius* (Table 1) we would like to mention that the dry matter contained 80 g/kg CP, 382 g/kg CF, 83 g/kg ash, 411 g/kg ADF, 710 g/kg NDF, 38 g/kg ADL, 118 g/kg TSS, 373 g/kg Cel, 299 g/kg HC. The tall oatgrass green fodder is characterized by a higher content of minerals and structural carbohydrates and lower concentration of total soluble sugars than the fodders from control variants. The *Arrhenatherum elatius* green fodder, as compared with the *Festuca pratensis* green mass has a higher content of crude protein, but as compared with the *Avena sativa* green mass, it contains a lower amount of acid detergent lignin. The high amount of neutral detergent fibre in oatgrass green fodder contributed to the reduction of digestibility, relative feed value and energy concentration.

Table 1. The biochemical composition and the nutritive value of the harvested green mass from *Arrhenatherum elatius*

Indices	*Arrhenatherum Elatius*	*Avena sativa*	*Festuca pratensis*	*Hordeum vulgare*
Crude protein, g/kg DM	80.00	95.00	71.00	119.00
Minerals, g/kg DM	83.00	65.00	80.00	75.00
Crude fibre, g/kg DM	382.00	356.00	359.00	349.00
Acid detergent fibre, g/kg DM ,	411.00	374.00	388.00	367.00
Neutral detergent fibre, g/kg DM	710.00	629.00	686.00	628.00
Acid detergent lignin, g/kg DM	38.00	46.00	33.00	29.00
Total soluble sugars, g/kg DM	118.00	167.00	174.00	163.00
Cellulose, g/kg DM	373.00	328.00	335.00	338.00
Hemicellulose, g/kg DM	299.00	258.00	298.00	261.00
Digestible dry matter, g/kg DM	561.00	598.00	587.00	603.00
Relative feed value	74.00	89.00	80.00	89.00
Digestible energy, MJ/ kg	11.18	11.84	11.64	11.92
Metabolizable energy, MJ/ kg	9.18	9.72	9.56	9.79
Net energy for lactation, MJ/ kg	5.31	5.73	5.57	5.81

In the specialized literature, there are data on the green mass quality of *Arrhenatherum elatius* plants. According to Skládanka et al. (2008) the forage dry matter from *Arrhenatherum elatius* plants contained 30.2% CF, 60.5% NDF, 35.9% ADF, 5.46 MJ/kg NEl; *Dactylis glomerata* plants -28.9% CF, 57.1% NDF, 35.1% ADF, 5.54 MJ/kg NEl; *Festulolium* plants contained 26.9% CF, 58.9% NDF, 32.3% ADF, 5.84 MJ/kg NEl. Tomić et al. (2005) reported that the grass quality of *Arrhenatherum elatius* grown the pasture associations was 6.28% CP, 30.07% CF, 8.11% ash. Reiné et al. (2020) studied the nutritional quality of meadow plant species and remarked that *Arrhenatherum elatius* contained 421 g/kg DM with 7.6% CP, 4.5% ash, 1.6% EE, 66.5% NDF, 35.2% ADF, 3.0% ADL, 61.5% DDM, 0.13% P, 0.50% Ca, but *Festuca arundinacea* contained 455 g/kg DM with 7.2% CP, 4.4% ash, 2.0% EE, 73.3% NDF, 41.1% ADF, 4.0% ADL, 56.8% DDM, 0.12% P, 0.35% Ca. Skládanka et al. (2010), compared the forage quality of grass green mass and found that the chemical composition of *Arrhenatherum elatius* plants was 7.92-9.49% CP, 29.34-30.25% CF, 55.48-61.20% NDF with 71.80-78.0% OMD; *Dactylis glomerata* plants - 9.00-9.17% CP, 27.52 -30.33% CF, 56.59-57.79% NDF with 70.4-76.9% OMD; *Festuca arundinacea* × *Lolium multiflorum* plants – 7.11-7.54% CP, 25.36-29.79% CF, 56.10-61.25% NDF with 71.8-78.0% OMD.

Hay represents a low-cost roughage source of nutrients and is vital to keep livestock healthy and productive, particularly in the autumn - middle spring period. We would like to mention that the hay prepared from tall oatgrass plants (Tables 2) contained 77 g/kg CP, 414 g/kg CF, 80 g/kg ash, 436 g/kg ADF, 740 g/kg NDF, 40 g/kg ADL, 98 g/kg TSS, 396 g/kg Cel and 304 g/kg HC. The digestibility and the energy concentration of the hay from tall oatgrass plants was 54.1% DDM, 10.82 MJ/kg DE, 8.88 MJ/kg ME and 5.02 MJ/kg NEl.

Table 2. The biochemical composition and the nutritive value of the hay from *Arrhenatherum elatius*

Indices	*Arrhenatherum elatius*	*Avena sativa*	*Festuca pratensis*	*Hordeum vulgare*
Crude protein, g/kg DM				
Minerals, g/kg DM	77.00	105.00	79.00	90.00
Crude fibre, g/kg DM	80.00	74.00	85.00	69.00
Acid detergent fibre, g/kg DM	414.00	381.00	364.00	435.00
Neutral detergent fibre, g/kg	436.00	404.00	391.00	456.00
DM	740.00	660.00	681.00	736.00
Acid detergent lignin, g/kg DM	40.00	50.00	32.00	45.00
Total soluble sugars, g/kg DM	98.00	111.00	153.00	51.00
Cellulose, g/kg DM	396.00	354.00	359.00	401.00
Hemicellulose, g/kg DM	304.00	256.00	290.00	280.00
Digestible dry matter, g/kg DM	541.00	574.00	584.00	534.00
Relative feed value	68.00	81.00	80.00	67.00
Digestible energy, MJ/ kg	10.82	11.40	11.59	10.69
Metabolizable energy, MJ/ kg	8.88	9.36	9.51	8.78
Net energy for lactation, MJ/ kg	5.02	5.39	5.54	4.79

During the process of preparing tall oatgrass hay, we observed an increase in the concentration of structural carbohydrates, lignin, and a decrease in the crude protein, minerals and total soluble sugar content, which has a negative effect on dry matter digestibility and energy concentration as compared to harvested green mass. The tall oatgrass hay is characterized by lower amount of crude protein, acid detergent lignin, total soluble sugars and minerals than common oat hay. As compared with the meadow fescue hay, the tall oatgrass hay did not differ significantly in the concentration of crude protein, but had high concentration of cell wall fractions (NDF, ADF, ADL), minerals and reduced content of total soluble sugars, dry matter digestibility and energy supply. The prepared tall oatgrass hay had lower content of crude protein, acid detergent fibre, acid detergent lignin and high content of total soluble sugars and minerals than hay prepared from the winter barley. According to Medvedev & Smetannikova (1981), tall oatgrass hay contained 7.6-12.7% CP, 1.6-3.4% EE, 23.2-32.0% CF, 36.0-50.0% NFE, 7.0-10.0% ash.

Silage fodder is a key element for good farm animal feeding. The investigated silage from *Arrhenatherum elatius* plants was distinguished by homogeneous light olive colour, pleasant smell specific of pickled watermelon, the consistency was preserved, in comparison with the initial green mass, without mould and mucus. The quality indices of the silage prepared from *Arrhenatherum elatius* are shown in Table 3.

The fermentation profile of the prepared tall oatgrass silage was pH = 4.26, 4.5 g/kg free lactic acid, 2.8 g/kg free acetic acid, 13.8 g/kg fixed lactic acid, 3.1 g/kg fixed acetic acid, butyric acid was not detected. It was determined that the pH of the tall oatgrass silage was higher, but the concentration of organic acids is lower than in the meadow fescue silage. The concentrations of nutrients in the tall oatgrass silage dry matter were: 88 g/kg CP, 405 g/kg CF, 100 g/kg ash, 420 g/kg ADF, 724 g/kg NDF, 26 g/kg ADL, 74 g/kg TSS, 394 g/kg Cel, 304 g/kg HC, with nutritive and energy value 56.5% DMD, 11.25 MJ/kg DE, 9.19 MJ/kg ME, 5.21 MJ/kg NEl.

As compared with the whole plant fodder in the *Arrhenatherum elatius* silage, there was detected an increase in the content of crude protein, minerals, cellulose and hemicellulose, and a reduction in the acid detergent lignin, the dry matter digestibility and energy concentration do not differ essentially. We would like to mention that *Arrhenatherum elatius* silage is characterized by a high content of cell wall fractions (NDF, ADF, ADL) and low content of crude protein, total soluble sugars, minerals, dry matter digestibility and energy concentration as compared with the control - winter barley silage. As compared with the meadow fescue silage, the tall oatgrass silage did not particularly differ in the concentration of structural carbohydrates, dry matter digestibility

and energy supply, but had high level of crude protein and acid detergent lignin and reduced content of total soluble sugars. Dinić et al. (2008) studied the biochemical composition of silages made of various crops, grown in Germany, and remarked that tall oat grass silage from plant mowing in earring stage had pH 4.38 and contained 308.3 g/kg DM with 5.28% lactic acid, 1.89% acetic acid, 0.76% butyric acid, 15.60% CP, 5.01% EE, 69.01% NDF, 33.87% ADF, 18.75%TSS, 35.13%HC, 10.44% ash, 0.54% Ca and 0.35% P, but the silage from plant mowing in the blooming stage respectively - pH 4.13, 322.5 g/kg DM 5.66% lactic acid, 2.14% acetic acid, 0% butyric acid, 13.82% CP, 4.82% EE, 70.44% NDF, 34.03% ADF, 15.93% TSS, 36.41% HC, 9.76% ash, 0.49% Ca and 0.31% P. Crop residues are important feed resources for livestock.

Table 3. The quality indices of the silage from *Arrhenatherum elatius*

Indices	*Arrhenatherum elatius*	*Festuca pratensis*	*Hordeum vulgare*
pH index	4.26	4.08	4.04
Organic acids, g/kg DM	24.20	42.10	38.40
Free acetic acid, g/kg DM	2.80	3.50	3.40
Free butyric acid, g/kg DM	0.00	0.00	0.00
Free lactic acid, g/kg DM	4.50	6.50	10.50
Fixed acetic acid, g/kg DM	3.10	4.30	3.60
Fixed butyric acid, g/kg DM	0.00	0.00	0.00
Fixed lactic acid, g/kg DM	13.80	27.80	20.90
Total acetic acid, g/kg DM	5.90	7.8.00	7.00
Total butyric acid, g/kg DM	0.00	0.00	0.00
Total lactic acid, g/kg DM	18.30	34.30	31.40
Acetic acid, % of organic acids	24.38	18.52	18.20
Butyric acid, % of organic acids	0.00	0.00	0.00
Lactic acid, % of organic acids	75.62	81.48	81.80
Crude protein, g/kg DM	88.00	80.00	129.00
Crude fibre, g/kg DM	405.00	394.00	338.00
Ash, g/kg DM	100.00	96.00	114.00
Acid detergent fibre, g/kg DM	420.00	411.00	347.00
Neutral detergent fibre, g/kg DM	724.00	718.00	571.00
Acid detergent lignin, g/kg DM	26.00	22.00	18.00
Total soluble sugars, g/kg DM	74.00	132.00	129.00
Cellulose, g/kg DM	394.00	389.00	329.00
Hemicellulose, g/kg DM	304.00	307.00	224.00
Digestible dry matter, g/kg DM	565.00	569.00	619.00
Digestible energy, MJ/kg DM	11.25	11.32	12.21
Metabolizable energy, MJ/kg DM	9.19	9.29	10.02
Net energy for lactation, MJ/kg DM	5.21	5.31	6.10
Relative feed value	73.00	74.00	100

The optimal use of straw in animal diets depends on the availability of detailed information on their chemical composition, biological properties and nutritional value, which may vary between type of agroecosystem, plant species, cultivars. The results regarding the nutritive quality of the *Arrhenatherum elatius* seed straw are shown in Table 4. It has been found that tall oat grass straw is characterized by high content of protein (50 g/kg), minerals (77 g/kg), total soluble sugars (85 g/kg) and low cell wall concentration (742 g/kg) compared with the control variants – winter barley and meadow fescue seed straws, which has a positive effect on nutritive value and energy concentration. Renewable energy sources coming from agricultural crops could play an important role in terms of energy supply and positive environmental effects. Bioethanol, a renewable energy source, is one of the alternatives to petroleum. The use of ethanol as a fuel for internal combustion engines has certain advantages as compared with gasoline: the octane number is higher, which leads to greater detonation resistance; the freezing point of ethanol is lower, CO_2 emissions are also lower. The production of cellulosic ethanol via biological conversion consists of three critical

steps: pretreatment of biomass, hydrolysis of sugar polymers (cellulose, hemicellulose etc.) to sugar monomers (hexose, pentose) and fermentation of sugar monomers to ethanol (Kumar & Murthy, 2011; Cerempei, 2016).

Table 4. The biochemical composition and the nutritive value of the straw from *Arrhenatherum elatius*

Indices	*Arrhenatherum elatius*	*Festuca pratensis*	*Hordeum vulgare*
Crude protein, g/kg DM	50.00	39.00	45.00
Crude fibre, g/kg DM	443.00	463.00	496.00
Ash, g/kg DM	77.00	75.00	59.00
Acid detergent fibre, g/kg DM	456.00	478.00	550.00
Neutral detergent fibre, g/kg DM	742.00	771.00	792.00
Acid detergent lignin, g/kg DM	51.00	54.00	68.00
Total soluble sugars, g/kg DM	85.00	72.00	79.00
Cellulose, g/kg DM	405.00	424.00	482.00
Hemicellulose, g/kg DM	286.00	293.00	242.00
Dry matter digestibility, %	534.00	517.00	461.00
Digestible energy, MJ/kg DM	10.69	10.38	9.38
Metabolizable energy, MJ/kg DM	8.78	8.52	7.71
Net energy for lactation, MJ/kg DM	4.79	4.54	3.72
Relative feed value	67.00	62.00	54.00

The composition of cell walls and the theoretical ethanol potential of investigated hay and straw substrates are presented in Table 5. We would like to mention that the investigated substrates of tall oat grass varied in terms of cellulose content (396-405 g/kg) and hemicellulose (286-304 g/kg), a fact that affected the concentration of pentose and hexose carbohydrates, and the theoretical bioethanol potential reached values of 507-509 l/t organic matter. In comparison with substrates from *Festuca pratensis* and *Hordeum vulgare* the hay substrate from *Arrhenatherum elatius* had higher bioethanol potential, but straw substrate - lower bioethanol potential values.

Table 5. The composition of cell walls and the theoretical ethanol potential of investigated substrates from *Arrhenatherum elatius*

Indices	*Arrhenatherum elatius*		*Festuca pratensis*		*Hordeum vulgare*	
	Hay	straw	hay	straw	hay	straw
Acid detergent fibre, g/kg	436.00	456.00	391.00	478.00	456.00	550.00
Neutral detergent fibre, g/kg	740.00	742.00	681.00	771.00	736.00	792.00
Acid detergent lignin, g/kg	40.00	51.00	32.00	54.00	45.00	68.00
Cellulose, g/kg	396.00	405.00	359.00	424.00	401.00	482.00
Hemicellulose, g/kg	304.00	286.00	290.00	293.00	280.00	242.00
Hexose sugars, g/kg	72.11	74.59	65.55	76.82	72.69	97.87
Pentose sugars, g/kg	50.00	47.04	47.70	48.20	46.05	39.81
Theoretical ethanol potential, L/t	509.00	507.00	472.00	521.00	495.00	574.00

Several literature sources describe the composition of cell walls in grass straw and its cellulosic ethanol potential. Goff et al. (2010) found that, for sorghum biomass, the theoretical ethanol potential ranged from 560 to 610 L/t of dry biomass. Kumar & Murthy (2011) reported that straw of tall fescue contained 94.6% solids, 10.6% ash, 6.7% CP, 19.08 % water extractives, 0.32% ethanol extractives, 32.4% glucan, 14.6% xylan, 2.9% galactan, 3.0% arabinan, 15.6% acid-insoluble lignin, 1.3% acid-soluble lignin and estimated ethanol potential to be 360.57 L/ton biomass. Danielewicz et al. (2019) mentioned that tall oatgrass biomass contained 34.7% cellulose, 15.4% lignin and 3.8% extractives; tall wheatgrass – 42.3% cellulose, 18.3% lignin and 2.3% extractives, tall fescue 34.6% cellulose, 15.9% lignin and 2.1% extractives and *Miscanthus* whole plant 40.5% cellulose, 20.6% lignin and 3.9% extractives. Doroftei et al. (2021) found that the studied straw of perennial grass seed crop contained 371-

518 g/kg cellulose and 223-314g/kg hemicellulose, the estimated theoretical ethanol yield varied from 432 to 605 L/t. Waliszewska et al. (2021) compared the chemical composition of grass species and remarked that *Arrhenatherum elatius* biomass contained 15.00% extractives, 35.46% cellulose, 17.54% lignin, 68.63% holocellulose, 33.17% hemicellulose, *Dacylis glomerata* respectively 10.59% extractives, 37.71% cellulose, 19.33% lignin, 69.19% holocellulose, 31.48% hemicellulose and *Phalaris arundinacea* - 12.77% extractives, 38.68% cellulose,15.42% lignin, 70.39% holocellulose, 31.71% hemicellulose.

The use of phytomass as substrate for biogas production directly harvested fresh mass or ensiled mass has recently become of major interest in Europe. The results regarding the quality of the *Arrhenatherum elatius* substrates and the potential for obtaining biomethane are shown in Table 6. We would like to mention that the nitrogen content in *Arrhenatherum elatius* substrates varied from 12.8 g/kg to 14.1 g/kg, the estimated content of carbon ranged from 500.0 g/kg to 509.0 g/kg, the C/N = 35.5-39.8, but the substrates from the control plant species contained 11.4-20.6 g/kg nitrogen, 492.2-519.0 g/kg carbon and C/N = 24-45. Essential differences were observed between the concentrations of acid detergent lignin and hemicellulose. As we have mentioned above, the process of ensiling decreased the lignin content and increased hemicellulose content, which had a positive effect on the activity of methanogenic bacteria. The biochemical methane potential *Arrhenatherum elatius* substrates varied from 341 l/kg VS in green mass substrates to 361 l/kg VS in ensiled mass substrates, being much higher than in *Avena sativa* substrate. The best biomethane potential were achieved in *Hordeum vulgare* silage substrates.

Table 6. The biochemical biomethane production potential of the investigated substrates from *Arrhenatherum elatius*

Indices	*Arrhenatherum elatius*		*Festuca pratensis*		*Hordeum vulgare*		*Avena sativa*
	green mass	silage	green mass	silage	green mass	silage	green mass
Crude protein, g/kg DM	80.00	88.00	71.0	80.00	119.00	129.00	95.00
Nitrogen, g/kg DM	12.80	14.10	11.4	12.80	19.00	20.60	15.20
Ash, g/kg DM	83.00	100.00	80.00	96.00	75.00	114.00	65.00
Carbon, g/kg DM	509.00	500.00	511.1	502.20	513.90	492.20	519.00
Ratio carbon/nitrogen	39.80	35.50	45.0	39.20	27.00	24.00	34.00
Acid detergent lignin, g/kg DM	38.00	26.00	33.0	22.00	29.00	18.00	46.00
Hemicellulose, g/kg DM	299.00	304.00	298.0	307.00	261.00	224.00	258.00
Biomethane potential, L/kg VS	341.00	361.00	347	367.00	361.00	379.00	329.00

There are different results reported in research studies conducted by other authors.

Ebeling et al. (2013) found that dependent of harvest dates and levels of fertilizer application the specific methane yield of *Arrhenatherum elatius* biomass substrates ranged between 311 and 347 l/kg VS; *Dactylis glomerata* substrates 313-334 l/kg; *Lolium perenne* substrates 320-335 l/kg VS and *Festuca rubra* substrates 312-331 l/kg VS.

Goliński & Goliński (2013) reported that the harvested biomass from the semi-natural grasslands that were mainly represented by *Arrhenatherion* alliance contained 308 g/kg dry matter, 10.35% CP, 6.36% ash, 50.98% NDF, 31.61% ADF and and methane yield was 338 l/kg VS. Boob et al. (2019) remarked that the methane yield of the biomass from *Arrhenatherion* grasslands was 300 l/kg VS. Von Cossel et al. (2019) found that the first-cut biomass substrate from *Arrhenatherion* grasslands were characterized by 240-297 g/kg DM, 7.0-8.1% ash, 4.7-5.7% lignin, 29.3-31.9% Cel, 20.7-25.2 % HC, 1.4-1.7% N and the methane yield ranged from 289 to 297 l/kg VS. Meserszmit et al. (2021) mentioned that the herbage from *Arrhenatherum elatius* and *Dactylis glomerata* plant community contained 8.00% CP, 3.17% EE, 57.30% NDF, 16.56% HC, 29.47% Cel, 11.24% lignin, 7.73% ash, and methane yield was 249 l/kg VS, but the herbage from *Agrostis capillaris* and *Festuca rubra* plant community - 9.29% CP, 2.71% EE, 55.73% NDF, 19.46% HC, 24.06% Cel, 12.21% lignin, 6.51% ash, and the methane yield was 244 l/kg VS, respectively.

CONCLUSIONS

The local ecotype of tall oatgrass, *Arrhenatherum elatius*, is suitable for grassland restoration and also may be used as fodder for livestock, also as substrate for bioethanol and biomethane production as a source of renewable energy.

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